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Does Information Technology Investment Influences Firm's Market Value? The Case of Non-Publicly Traded Healthcare Firms

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RESEARCH NOTE

DOES INFORMATION TECHNOLOGY INVESTMENT INFLUENCE A FIRM'S MARKET VALUE? A CASE OF NON-PUBLICLY TRADED HEALTHCARE FIRMS[1]

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Managers make informed information technology investment decisions when they are able to quantify how IT contributes to firm performance. While financial accounting measures inform IT's influence on retrospective firm performance, senior managers expect evidence of how IT influences ***prospective*** *measures such as the firm's market value. We examine the efficacy of IT's influence on firm value combined with measures of financial performance for non-publicly traded (NPT) hospitals that lack conventional market-based measures. We gathered actual sale transactions for NPT hospitals in the United States to derive the q ratio, a measure of market value. Our findings indicate that the influence of IT investment on the firm is more pronounced and statistically significant on firm value than exclusively on the accounting performance measures. Specifically, we find that the impact of IT investment is not significant on return on assets (ROA) and operating income for the same set of hospitals. This research note contributes to research and practice by demonstrating that the overall impact of IT is better understood when accounting measures are complemented with the firm's market value. Such market valuation is also critical in merger and acquisition decisions, an activity that is likely to accelerate in the healthcare industry. Our findings provide hospitals, as well as other NPT firms, with insights into the impact of IT investment and a pragmatic approach to demonstrating IT's contribution to firm value.*

Keywords: IT payoff, firm valuation, non-publicly traded hospitals, NPT, health care, firm performance, market value

Introduction

Recent and past studies have established that information technology contributes to a firm's financial performance through improved productivity, higher profitability, and enhanced consumer value (Dewan and Ren 2011; Kohli and Devaraj 2003; Mithas et al. 2012; Ramirez et al. 2010; Ravichandran and Lertwongsatien 2005;). Firm-level productivity and profitability performance indicators reflect managerial proficiency in resource utilization and organizational control. However, value from IT investments is realized at

[1]Mike Morris was the accepting senior editor for this paper.

multiple levels—process, firm, and market (Davern and Kauffman 2000; Henderson et al. 2010; Kobelsky 2008)—and investment in IT has the potential to enhance a firm's market value, an outcome that is of considerable interest to senior managers and other stakeholders. Investment in IT and the subsequent increase in a firm's market value are vital to sustaining corporate viability and prosperity (Bacon 1992). As recent evidence indicates, failure to invest in IT can influence a firm's operations in ways that can adversely affect its market value (Yayla and Hu 2011).

While publicly traded firms have been able to examine the influence of IT on firm value (e.g., using return on equity), non-publicly traded (NPT) firms, particularly hospitals, have not been able to do so because they lack a stock price. Among the studies that measured IT impact using market-based equity variables, few have explicitly examined the relationship between IT investment and its impact on the firm's *q* ratio, a measure of firm value (Bharadwaj et al. 1999), and none in the context of hospitals. Our single industry setting of NPT hospitals provides an important context given that the healthcare industry now exceeds 16 percent of the U.S. economy. Studies that focus upon a single industry are less susceptible to offsetting impacts of IT on firms of one industry by those of another industry due to differences in regulation, trade practices, and the nature of IT. In this study, we utilize actual sale transactions of hospitals to arrive at firm value, a robust measurement approach that is also consistent with practice.

Investments that enhance a firm's market value are of enormous interest to hospital managers, for example, to raise capital for expansion of services or to evaluate opportunities for mergers and acquisitions. Escalating healthcare costs have led to consolidation in the U.S. hospital industry in the last decade (Krishnan and Krishnan 2003) and is likely to continue following the United States' passage of the Patient Protection and Affordable Care Act of 2010, which seeks further cost control through IT investment and greater sharing of best practices among hospitals (DoBias 2009). These changes will require managers to carefully assess and demonstrate how IT investments influence their hospital performance as well as the firm's overall market value (Goldstein 2010).

Our findings indicate that IT investment among NPT hospitals is significantly and positively related to their market value. We find that IT's influence on hospital value might not be evident if solely profitability measures such as operating income were deployed. Therefore, employing a market value-based measure combined with traditional accounting performance measures can provide valuable insights for hospital managers and instill greater confidence in establishing the impact of IT investments on the current and future value of the firm. Our objective is not to proclaim superiority of one form of performance metric over another metric; rather, the purpose of this research note is to propose that managers are better served when firm-level accounting measures of efficiency and profitability are supplemented with prospective market-level measures that take into account the firm value because it informs managers how IT investment influences value that the market bestows upon the firm, as has been called for previously by IS scholars (Sambamurthy 2001).

This research note makes three primary contributions to IS research. First, it establishes that IT investment does indeed influence NPT firm market value, evidence that was scarce for decision makers who needed to evaluate and prioritize various investment options of which IT is one. Second, by articulating the role of IT investment in hospitals, it contributes to the growing IS academic interest in healthcare,[2] a leading economic sector that has been underrepresented in previous studies. Third, it offers future researchers a methodology that can be applied to value other NPT firms. NPT firms are usually viewed as small and medium enterprises (SME), trusts, and semi-governmental organizations; however, NPT firms also include very large, multibillion dollar businesses across various sectors including healthcare.[3] This methodology can also be extended to assess the impact of other investments, such as plant and machinery, on NPT firm value.

The paper is organized as follows. We begin with the theoretical grounding for examining IT's role in firm value, then review previous literature in IT and firm value, established approaches to firm valuation, and their importance in the valuation of NPT hospitals. Next, we develop two hypotheses to test the relationship between IT investment and the firm value or the *q* ratio, and the efficacy of the *q* ratio in identifying the influence of IT investment. In the "Methods" section, we present data sources and description of variables, followed by the results. Finally, we present our conclusions, contribution to IT research, and suggestions for future research.

[2]Two leading IS journals—*Information Systems Research* (ISR) and *Journal of Association for Information Systems* (JAIS)—have recently devoted special issues to healthcare IT.

[3]Among the Financial Times 150 non-public firms, those registered in the United States include State Farm, Nationwide, USAA, Liberty Mutual (insurance); Cargill, Inc. (food and agribusiness); Kaiser Permanente, Acension Health (healthcare); Vanguard Group, TIAA-CREF (asset management); PriceWaterhouseCoopers (consulting); and SC Johnson (consumer goods).

Theoretical Background

Information Technology Investment and Firm Value

Understanding the relationship between investments and firm value has long been of interest to researchers. Of particular interest are investments in apparatus and processes, such as IT, that enable firms to create innovative products and services (e.g., Griliches 1981). Previous studies attempting to understand how IT investments influence firm value examined the market reaction to announcements of IT investment. Generally captured through event-study methodology, these studies track IT investment announcements (event) followed by an examination of the change in firm value (e.g., variation in stock price). Dos Santos et al. (1993) found mixed results following the announcements of IT investment and no overall excess returns in firm value. Henderson et al. (2010) suggest that this may be due to a lack of reliable and verifiable public information about the nature of IT spending. Along these lines, the market may delay bestowing value solely based upon announcements to mitigate the potential risk, especially for expenditures (e.g., ERP) that have had mixed results (Hitt et al. 2002; Im et al. 2001). Recent event-study research has examined the impact of IT- related application service provider (ASP) adoption on firm value (Jeong and Stylianou 2010) and the adverse impact of IT investment failures on firm value (Bharadwaj et al. 2009) as well as diminishing returns from IT that was once considered value enhancing (Dos Santos et al. 2012). Although announcements provide an early indication of the market's assessment of value, these mixed results suggest that the link between IT investment and firm value needs to be explored further.

In contrast to event-studies, several other studies have utilized IT expenditures' influence upon accounting measures (e.g., productivity and profitability)[4] and market-based measures (e.g., stock price and returns) as proxies for firm value. Some studies have examined both accounting and market measures to assess IT's influence (e.g., Anderson et al. 2006; Henderson et al. 2010; Kobelsky et al. 2008). Table 1 provides a sampling of previous studies and their salient findings. In an early study seeking IT's influence on firm productivity, profitability, stock market value, and consumer surplus, Hitt and Brynjolfsson (1996) found that IT investment increased productivity and consumer value but found no significant relationship between total shareholder return, a market-based measure, and IT investment. They attributed the lack of IT's impact, in part, to the mix of productive and unproductive firms in the data set and argued that lack of granularity in the data made it difficult to identify whether IT influenced market measures. Anderson et al. (2006) utilized a stock price based market value to book value ratio and found no significant influence of Y2K-related IT investment among a cross-section of firms from various industries. However, upon categorizing industries engaged into automate, informate, and transform types, they found that IT investments positively influence firms in "transform" industries. Both Hitt and Brynjolfsson (1996) and Anderson et al. (2006) highlight the importance of industry in understanding how IT influences firm value, a contribution we aim to make in this research note.

Kobelsky et al. (2008) are among the few scholars who explicitly examined IT's influence on accounting as well as market-based measures across industries and found positive influence of IT on both sets of measures. As in other cross-industry studies, they accounted for potential industry effects in the analysis. A salient finding of this study is that a firm's market value may be misstated because publicly available market value information is imperfect. This is because firms generally report aggregate spending data in which IT investments are not explicitly disclosed. Such information asymmetry may explain IS researchers' interest in event studies involving announcements (as discussed above) that publicize IT investments to potential investors and market participants.

Our review of literature indicates that, although empirical models incorporating IT expenditures significantly explain the change in *q* ratio (Bharadwaj et al. 1999), relatively few empirical studies have used *q* ratio as a dependent variable. The *q* is computed as the ratio of a firm's equity market value (minus liabilities) to the replacement value of its book value where values above "1" indicate the firm's ability to create supra-normal value for its stakeholders. For publicly traded firms, the market worth is calculated as the product of stock price and total number of stocks, and the replaceable assets are the plant, machinery, warehouses, etc. Given that the numerator of the *q* ratio is the stock price, it can be assumed that it takes into account the risks as well as the intangible benefits of IT. In doing so, the market-based firm value captured through the *q* ratio represents a forward-looking approach and complements the retrospective firm performance captured in financial accounting measures.

Dehning et al. (2005) developed a theoretical model to examine components of firm value that include industry and firm specific effects as well as the duration and magnitude of IT expenditures. Consistent with previous findings, Dehning et al. recommend using firm value to evaluate benefits of IT

[4]For literature reviews, please see Dehning and Richardson (2002), Kohli and Devaraj (2003), and Melville et al. (2004).

Table 1. Illustrative Studies in IT Investment and Firm Performance

Study	Analytical Approach	Measure Type(s)	Independent Variable(s)	Dependent Variable(s)	Key Findings
Dos Santos et al. (2012)	Event analysis	Market	Announcement of new-information macroeconomic events	Variation in stock price	IT investments to sustain current application are not affected by economic conditions; investments in new IT application are affected. IT value of products considered as value-enhancing decline over time.
Mithas et al. (2012)	Panel regressions	Accounting	Annual IT budget, operating expense, sales, R&D, industry (q ratio, capital industry)	Net income	IT has a positive impact on profitability. The effect of IT investments on sales and profitability is higher than that of other discretionary investments advertising and R&D expenditures.
Dewan and Ren (2011)	SUR regression	Market	Firm diversification, vertical integration index, non-IT and IT capital, R&D, advertising, size, long-term debt	ROA, stock returns; risk measured as std. dev. of ROA, stock returns and analysts earnings forecast	Increased IT investment with greater firm diversification results in higher returns and lower risk.
Henderson et al. (2010)	Regression	Market and Accounting	IT expenditures, R&D, advertising, capital expenditures	Market value, book value, earnings	IT expenditures explain future performance. Lack of reliable information of IT spending may lead markets to misprice
Ramirez et al. (2010)	Regression based Cobb-Douglas production function	Market	IT and ordinary capital, labor, extent of BPR, risk	Market value, value added	IT investment combined with BPR has positive return on value added and firm market value.
Kobelsky et al. (2008)	Regression	Market and Accounting	IT budget level	Operating return on sales, return on assets; stock performance	IT budgeted levels influence both firm performance and shareholder returns. Context driven and idiosyncratic IT budget levels have differential impacts.
Parente and Van Horn (2007)	Logistic regression	Accounting	Mean IT tenure, total assets costs, size (beds, discharges, inpatient days)	Operating return on assets	Marginal effect of IT adoption on for-profit productivity is to reduce number of days supplied (costs), while in not-for-profit hospitals is to increase services supplied (patient volume).
Anderson et al. (2006)	OLS regression	Market and Accounting	Y2K spending, earnings, R&D, sales growth, asset growth	Ratio of market value to book value	Y2K related IT spending increased firm value in industries where IT plays a transforming role but not among other industries
Brynjolfsson et al. (2002)	OLS; least absolute deviation (LAD) regression	Market	Expenditures in PP&E, R&D, advertising, labor and capital, dollar value-added, organizational structure	Market value of equity	Financial markets place higher value on firms with greater installed computer capital. Firms that make complementary investments in organizational changes command higher market value.
Im et al (2001)	Event analysis	Market	IT investment announcement, firm size, industry classification, and price and volume reaction to announcement	Abnormal return and volume (changes in stock price and trading volume)	The mixed positive excess returns indicated that smaller firms could better leverage the lower price/performance ratio of new IT and extract greater value from IT investments than larger firms.

Table 1. Illustrative Studies in IT Investment and Firm Performance (Continued)

Study	Analytical Approach	Measure Type(s)	Independent Variable(s)	Dependent Variable(s)	Key Findings
Menon et al. (2000)	Cobb-Douglas production function	Accounting	Capital expenditure (IT, medical IT, and medical), labor (IT and non-IT)	Hospital revenue from patient charges	Both IT and Medical IT capital have a positive influence on production of service in hospitals
Devaraj and Kohli (2000)	Regression	Accounting	IT (labor, support and capital) expenditures, BPR	Hospital revenue, patient mortality, and satisfaction	IT investment leads to greater profitability and quality outcomes among hospitals
(Bharadwaj et al. 1999)	OLS regression	Market	Industry— concentration, *q* ratio, capital intensity, regulation Firm—market share, diversification, employees, advertising expenditure, R&D	Tobin's *q*	IT investments contribute to the future performance potential and are positively associated with the Tobin's *q* measure
Hitt and Brynjolfsson (1996)	OLS based Cobb-Douglas production function	Accounting	IT stock, non-computer capital, capital intensity, debt/equity ratio, market share, labor, sales growth	ROA, return on equity	IT investment increased productivity and consumer value but not firm profitability.
Dos Santos et al. (1993)	Event analysis	Market	Announcement of (non)innovative IT investment	Variation in stock price	Mixed results following announcements of IT investments. Innovative IT investments increase firm value

expenditures because firm value accounts for short-term and long-term benefits to the firm while overcoming the lag between implementation and payoff of IT. Although researchers have been urged to pursue research that establishes the relationship between IT expenditures and the firm's market value (e.g., Sambamurthy 2001), *q*-based firm value as a dependent variable has been used sparingly in favor of accounting measures of productivity and profitability outcomes (Kohli and Devaraj 2003).

NPT Hospitals and Firm Value

Given that publicly traded firms account for less than one-third of gross domestic product (GDP),[5] a large number of firms are NPT without a market-based stock price and thus are unable to assess the *q* ratio. Therefore, they must utilize alternative approaches to arrive at the *q* ratio to establish firm market value.

Hospitals constitute a significant portion of U.S. healthcare providers and support one out of 10 jobs. More than 60 percent of U.S. hospitals are NPTs, including several multi-billion dollar organizations.[6] Previous literature on valuation for NPT firms, including hospitals, has established three methods to calculate firm value: (1) income, (2) market, and (3) cost (Mitenko and Okleshen 1998). The United States' Government Accountability Office (GAO) has endorsed these three methods as "generally accepted methods" for hospital valuation (Stark and Coyne 1997). Briefly, the *income* method approaches valuation by examining the earnings before interest, taxes, depreciation and amortization (EBITDA) and then uses competitor firms' multiple of EBITDA to determine firm value. The *market* valuation method involves two steps: an analysis of comparable companies and a precedent transaction analysis. This analysis compares the value of an NPT hospital to the value of an equity-based hospital listed on the stock market by utilizing its EBITDA multiples of market value derived from transaction prices for recent and comparable firms. Finally, in the *cost* method, the

[5]For information, go to the U.S. Small Business Administration Office of Advocacy website (www.sba.gov/advo).

[6]Among U.S. hospitals, 62 percent are nonprofit, 18 percent are for profit, and the rest are government owned. The 2010 Fortune 500 consists of 14 health systems (each include multiple hospitals) such as Methodist Hospital System, Mayo Clinic, and Meridian Health.

firm value is calculated by determining the cost to replace or reproduce an asset, after making an allowance for physical deterioration or obsolescence. This amount minus the book value of liabilities equals the net value of firm assets.

An examination of these methods indicates that the denominator of *q* (replaceable assets) incorporates the *cost* method and the numerator (i.e., market value) can be calculated using either the *income* or *market* methods, or both. Comparative value and EBITDA multiples to calculate the market value take into account market-based intangible value that is represented in the stock price. Thus, one or more of the GAO-endorsed methods can be used to calculate *q* for NPT firms if hospital performance and other indicators are demonstrated as relevant to the hospital's market value. Our interviews with healthcare executives[7] who were actively involved in hospital mergers and acquisitions corroborated our findings that earnings and revenue play a fundamental role in valuing a hospital. They cautioned, however, that a strategic purchase (e.g., to consolidate a market in a geographic area) can confound the market value of the acquired hospital.[8] From a practical perspective, the *q* is parsimonious, less volatile than stock price, and simple to communicate. As proposed by Bharadwaj et al. (1999) and Dehning et al. (2005), its relative valuation spreads any potential market value bias across a number of comparable firms and thus reduces uncertainty in valuation.

IT Investment and the q Ratio

The business value of IT literature provides evidence that IT investment positively impacts firm value. The impact on firm value among publicly traded firms can be measured through measures such as stock price, return on assets, and *q* ratio. Bharadwaj et al. (1999) assert that a component of a firm's *q* ratio can be attributed to its IT capabilities. These findings are consistent with the notion that IT contributes to a firm's future performance potential through agility, flexibility, and process superiority that increase a firm's competitiveness (Sambamurthy et al. 2003), and that the market and investors recognize the strategic value of the IT investment which in turn is reflected in a higher *q* ratio (Brynjolfsson et al. 2002).

IT investments can also create intangible assets in the form of *options* that enable the firm to react and adapt to a fast changing marketplace (Balasubramanian et al. 1999; Benaroch 2002). Among hospitals, these options are achieved through standardized electronic health records (EHR) that enable hospitals to improve patient care quality by integrating various systems. However, the impact of such investment is likely to emerge in accounting measures following a delay and after the firm has exploited the option. In contrast, the strategic value of the IT investment (e.g., resulting from announcements) is likely to be recognized by the market sooner through higher stock price. Brynjolfsson and Hitt (2000) suggest that because IT investments require additional investment in intangible capital and the *q* ratio's ability to capture the intangible capital, its use in determining firm value is on the increase. They conclude that such intangible capital leads to substantial assets that are valued by the market and investors. The value placed by market investors on IT investments is substantiated by another study that found that as longer time periods are considered, firms with higher intangible assets demonstrate higher productivity (Brynjolfsson et al. 2002). Therefore, one can expect that following an IT investment, the market will place a higher value on the firm, even though the productivity gains may not occur until sometime in the future. As a result, there have been calls in the IT research community to consider measures that help identify the contribution of IT investment in firms and to utilize higher level measures such as the *q* ratio (Sambamurthy et al. 2003).

Consistent with the above arguments, the integration and efficiencies resulting from IT investment in hospitals are likely to lead to competitive market positioning (Feachem et al. 2002) and transformation of the delivery of healthcare (Haux 1998). Some examples are computerized physician order entry (CPOE) systems (Chaffee and Zimmerman 2010), or adverse drug event (ADE) tracking systems and physician profiling systems (Piontek, et al. 2010) that can be integrated and further enrich EHR over a period of time, a capability that can make it easier for hospital partners (e.g., physicians' offices, drug suppliers, insurance companies) to exchange information and funds. Recent evidence indicates that synergies from cross-business information technology integration reduces the costs of doing business, results in better compliance, reduces disruptions, and increases the acquirer's value creation (Taniverdi and Uysal (2011). As such, the duration of IT deployment among hospitals was found to be positively associated with marginal value of IT, which is accomplished through lower costs and higher productivity (Parente and Van Horn 2007).

Madison (2007) argues that hospital mergers can also lead to improvement in the quality of patient care because merged

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[7]Hugh Jones, Senior VP, Strategy & System Development, at Mount Carmel Health System; Mark Sibben, Senior Vice-President, Holy Cross Health System; Susan Murray, Director of Corporate Development, and George Glusko, Analyst, Corporate Development, Trinity Health.

[8]Interview with James Peppiatt-Combes, Chief Financial Officer, Trinity Health. Our data set excluded strategic purchases and bankruptcies of hospitals.

hospitals are able to concentrate their service offerings into higher quality facilities. Higher volumes among merged hospitals further enhance quality due to learning effects. From an IT perspective, the larger the number of electronic health records (EHR) users, the greater the benefit to the hospital due to network effects (Madison 2007). This leads us to propose that, due to the higher efficiency and quality expected from greater IT investments in hospitals, investors are likely to place higher market value when purchasing bonds or during mergers or acquisitions consideration. Therefore, we hypothesize that the IT investment will result in a higher firm value reflected in the *q* ratio for NPT hospitals. Thus, our first hypothesis is

> *Hypothesis 1: IT investment will be positively related to firm value (q ratio) for NPT hospitals.*

As discussed earlier, the value of IT investments is traditionally captured through retrospective measures such as net operating income and return on investment (ROI). We propose that a basket of measures that includes retrospective as well as prospective measures of firm value (*q* ratio) will provide a more comprehensive picture of the influence of IT investment on the firm.

Market value yields insights into how investors in the market evaluate a firm's investments. Accounting data, on the other hand, provide information on how the firm used its resources (Lindenberg and Ross 1981). Standard accounting measures (e.g., revenue) allow managers to compare their firm's performance with that of its competitors. However, researchers have questioned the relevance of solely accounting-based metrics to investors and have argued that differences in expensing methods for large investments can artificially depress earnings and understate the value emanating from such investments. As such, the complementarity between accounting information and other indicators of value may be a preferred approach to inform investors (Amir and Lev 1996). To the extent that IT investment is in a tactical area and aims to increase efficiency and productivity, accounting measures will continue to serve well. However, as IT investment increases in supporting or creating strategic initiatives, such as CPOE, ADE tracking, and EHR, it is likely that the impact will be manifested in forward-looking prospective measures of market value such as *q,* a notion that has been supported by the event-methodology studies. Second, IT investments yield time-lagged effects (Brynjolfsson et al. 2002; Kohli and Devaraj 2003) and, therefore, their impact might not be immediately evident in contemporaneous accounting measures. Furthermore, the efficient market hypothesis proposes that the markets take into account all public information pertaining to investments in arriving at a price or firm value.

Taken together, previous literature has established that the value of IT investments is manifested in two components: (1) accounting measures that capture the firm's efficient deployment of resources, and (2) market measures, also represented by the *q,* that capture the firm's market value. Market value incorporates deployment of strategic resources (e.g., IT assets) that are either not captured as replacement costs in the accounting measures, or will emerge sometime in the future. (For a theoretically constructed rationale of the salience of *q*, see Lindenberg and Ross 1981). Each set of measures offers certain advantages that, when taken together, offer a more complete picture of the contribution of IT to the firm. Therefore, our second hypothesis examines the notion that inclusion of *q* will expand our understanding of the influence of IT on the firm.

> *Hypothesis 2: The influence of IT investment is better captured when using a basket of measures that includes the q ratio for NPT hospitals than solely by traditional financial and accounting measures.*

Methods

To evaluate the measurable impact of IT investment on a hospital's value, the first step is to determine firm value. Given the absence of a stock price for NPT hospitals and the evident significance of *q*, we estimate a market-based measure of firm value to compute the *q* for hospitals (Appendix A provides a description of drivers of hospital market value and the calculation of the *q* measure for hospitals).

Data Description

Our data of *actual* transactions of purchase and sale of acute care hospitals were gathered from *The Health Care Mergers & Acquisitions Report* produced by Irving Lewis Associates, Inc. (ILA). To compile the report, ILA gathers data from various sources such as press releases, newspapers, SEC filings, Medicare Cost Report, and interviews with hospital personnel, and is a widely used information source for hospitals pursuing a sale, purchase, merger, or acquisition. This data contains price of hospitals sold as well as hospital characteristics such as EBITDA, size, and revenue. This objective hospital sale data is supplemented with expert assessments that summarize the background of the transaction such as whether it was a strategic buy (e.g., to consolidate market position) or the result of a bankruptcy. We removed strategic purchases and bankruptcies from our data set because it is likely that the transaction price is inflated or deflated, respectively, and may not reflect the true market value of comparable hospitals.

Our final sample of hospital sales data consists of 146 hospitals in the United States after list-wise deletion of missing observations and exclusion of strategic purchases and bankruptcies. For robustness, we compared the characteristics of these hospitals with all other U.S. hospitals and did not observe a statistically significant difference (at .05 significance level). Next, based on variables derived in Appendix A, we estimated a regression model relating EBITDA, size, and revenue to the market value of hospitals. It was reassuring that a significant amount of the variation (87.7 percent) in market value is captured by these variables. Thus, we use the coefficients obtained to compute predicted market value in the larger data set described below (see Appendix A for the estimated model as well as bootstrapping to ensure the robustness of our analysis and results). To test the effectiveness of the computed *q*, we used a commercially available and industry standard database—HCIA (now Thomson Reuters' Solucient) database—comprising financial and operations data for hospitals (HCIA 2001). The HCIA database consists of over 500 data fields for each hospital licensed by the U.S. government to accept Medicare and Medicaid patients by the Health and Human Services (HHS) Department of the United States Federal government. HHS disclosure regulations require each hospital to submit a report listing detailed financial, productivity, and expense data. The HCIA/Solucient database acquires and organizes these data and offers a subscription-based access. This stage of our analysis used data from 419 U.S. hospitals that reported IT spending to the U.S. government.

As discussed in the earlier section, we utilize GAO's *market* valuation method for NPT hospitals and use historical sales transactions of other comparable acute care hospitals, combined with the EBITDA, net patient revenue, and size of the hospital.

Variables

Dependent Variables

To better understand the contribution of the prospective and retrospective measures in impacting the hospital value, we utilize several dependent variables: *q* ratio and three traditional financial measures of performance—return on assets (ROA), operating income (OPINC), and total net income (TOTNETINC). The *q* was computed for each hospital as a ratio of market value divided by the total assets (which is a line item in the disclosure statements by hospitals).

The *q* ratio calculated is in the range of .05 to 3.92 with a mean of 1.34 and standard deviation of 0.8. This is comparable to the means and standard deviation obtained with *q* values published for the publicly traded firms that had a reported mean of 1.47 and standard deviation of 0.8 (Chari et al. 2008). The second set of dependent variables is the commonly assessed accounting metrics of hospital performance and has been utilized in previous hospital profitability studies (Gapenski et al. 1993; Langland-Orban et al. 1996; Shi 1996).

Independent and Control Variables

The correlations between the variables used (defined in Table 2) in the various estimation models are presented in Table 3. The number of hospital in our sample is 497. The mean size of the hospital denoted by the number of full time employment is 1,544 and the mean number of beds is 257. The mean age of the hospitals is 14.36 years. The mean IT investment is over $4.5 million. The focal independent variable is *IT investment,* drawn from costs reported by the hospitals to the U.S. federal government and available in the HCIA/Solucient database. These expenses are further divided as direct, indirect, and support. The U.S. federal government has a standard definition of how all hospitals must report expenses. These definitions clearly delineate which expenses are included or excluded. An unauthorized deviation from the defined expenses by a hospital attracts severe penalties or forfeiture of license. Hospitals strive to report accurate expenses, including IT expenses, because it entitles them to the optimal level of reimbursement for services. The IT expenditure related variables include expenses for information systems toward direct patient care. This expense category excludes equipment upgrade and maintenance, consulting, technical training, and other expenses that are not directly related to patient care. It is an annual IT expenditure for each hospital and represents IT hardware, software, and services toward the delivery of patient care. It is likely that the IT configuration and use varied among hospitals; however, given our focus on firm value, we examine reported input and outcome variables that account for such variation. Since hospital performance is also affected by variables other than IT investment, we surveyed the extant literature in healthcare management for determinants of healthcare productivity and profitability to identify appropriate control variables (Devaraj and Kohli 2000; Gapenski et al. 1993; Krishnan and Krishnan 2003; Langland-Orban et al. 1996; Parente and Van Horn 2007; Shi 1996). The following variables are drawn from the extant literature.

- *Age of Hospital (AGE)*: The age of the hospital, measured in years, can influence performance. Newer hos-

Table 2. Definition of Variables

Variable	Description
q ratio†	Ratio of Market Value to Total Assets
Asset or Book Value (BV)*	Total Assets of hospitals
Market Value (MV)†	Market Value: computed through Price Prediction Model (Appendix A)
ROA*	Return on Asset of hospital
OPINC*	Operating Income of hospital
TOTNETINC*	Total Net Income of hospital
IT INVESTMENT*	IT Investment
AGE*	Age of Hospital in years
TEACH HOSP*	Dummy variable represent Teaching/non-teaching status of hospital
OCCUPANCY*	Occupancy rate is measured as percent occupancy for a given hospital
ALOS*	Average Length of Stay measured in days for hospital
FTE*	Full Time Equivalent (Employees) of hospital

*HCIA/Solucient Database
†Calculation (see Appendix A)

Table 3. Correlations Between Variables Employed in Study

	1	2	3	4	5	6	7	8	9	10	11
1. *q* ratio	1										
2. Asset (BV)	.11**	1									
3. Market Value (MV)	.34***	.70***	1								
4. ROA	.17***	.10*	.30***	1							
5. OPINC	.17***	.13*	.33***	.84***	1						
6. TOTNETINC	.23***	.42***	.79***	.51***	.52***	1					
7. IT INVESTMENT	.27***	.64**	.77***	.16***	.19***	.61***	1				
8. AGE	-.04	-.01	-.05	-.05	-.09*	-.08	.04	1			
9. TEACH HOSP	.27***	.44***	.49***	.03	.05	.24***	.39***	-.03	1		
10. OCCUPANCY	.31***	.46***	.50***	.07	.10**	.24***	.40***	.01	.41***	1	
11. ALOS	-.22***	-.13***	-.13***	-.09*	-.09*	-.06	-.10**	-.03	-.17***	-.30***	1
12. FTE	-.03	.15***	.10*	-.02	-.06	-.06	.15***	.01	.08	.03*	.04

Significance: *< 0.1, **< 0.05, ***< 0.01

pitals are equipped with efficient technology and may better utilize their resources.

- *Teaching Hospital (TEACH HOSP)*: Teaching hospitals are generally affiliated with a medical school and may incur higher costs to maintain their teaching-related infrastructure. Traditionally, teaching hospitals have been viewed as institutions that provide cutting-edge healthcare because the physicians have a dual role of practitioner as well as researcher/teacher that enables them to be aware of the latest trends in healthcare.

- *Average Length of Stay (ALOS)*: This is measured as the average of the number of days in hospital for all patients and is reported in the HCIA/Solucient database for all hospitals in our sample. Prior studies in healthcare management identify and utilize ALOS as a key variable in understanding the difference among hospitals' performance (Gapenski et al 1993; Langland-Orban et al. 1996). This is because ALOS is an indicator of quality and efficiency and, all things being equal, the shorter the stay of patients, the lower the hospital's costs.

- *OCCUPANCY*: The capacity utilization of the hospital is measured as the occupancy rate (expressed as a percent) and can significantly affect hospital revenue.

- *Full Time Equivalent (FTE)*: The number of full-time equivalent employees is a standard proxy for organizational size. Organizational studies have used size as a control variable to account for effects due to scale of operation.

- *Market Value (MV)*: The market price of a hospital modeled after considering actual sales transactions and using bed size, net patient revenue, and EBITDA (for details, see the Price Prediction Model in Appendix A). This constitutes the numerator of the computed *q* ratio.

Results

Impact of IT Investment on Hospital Market Value

We estimated several models to examine the impact of IT investment on hospital performance. The following equation is representative of models employed to estimate the relationship between IT investment and market value while controlling for various extraneous factors through the use of control variables.

$$q = \beta_0 + \beta_1\, IT\ INVESTMENT + \beta_2\, AGE + \beta_3 TEACH\ HOSP + \beta_4\, OCCUPANCY + \beta_5\, ALOS + \beta_6\, FTE + e$$

We checked for the assumptions of normality and constant variance. The Kolmogorov-Smirnov normality test did not indicate violations of the normality assumptions. Plots of the residuals also confirmed the same. White's test for heteroscedasticity did not suggest a violation of the constant variance assumption. We also checked for multicollinearity using variance inflation factors (VIF) as well as the Belsley-Kuh-Welsh criteria. VIF reported in Tables 4 and 5 did not exceed the cutoff criteria of 10 and thus are not a cause for concern.

Our first set of results in Table 4 (Regression A) corresponds to the relationship between the market value *q* ratio and IT investment after controlling for various extraneous factors commonly employed in healthcare research. IT investment is statistically significantly (at the 0.01 level) related to *q* ratio. As can be seen, there is a strong positive relationship between the *q* ratio and IT investment, lending support for Hypothesis 1.[9]

We obtain several other insights from these analyses. First, the *q* is positively related (at the 0.01 level of significance) to occupancy of hospitals. In other words, the level of utilization of resources in the hospital might be a significant predictor of a forward-looking measure such as the *q* ratio. Next, the ALOS is negatively related to *q*. As discussed earlier, ALOS can be used as an indicator of quality and efficiency and is consistent with the general expectation that the market views hospital efficiency in a positive light. Given that under the prospective payment system a fixed amount is reimbursed (after taking into account severity, comorbidities, etc.) for a patient's stay, the sooner the patient is treated and discharged, the lower the hospital's costs and the higher its profit margin. Finally, the results indicate that 23 percent of the variation in *q* is explained by the model.

Alternate Model Specifications

While the model presented in Table 4 (Regression A) represents an estimation model using control variables well established in the healthcare management literature, there are other types of models presented in the IS literature. Most prominent among these is the relationship between IT and market value (as a proxy for Tobin's *q*) presented in Tam (1998). Following Tam, we estimate the following model:

$$Log\ MARKET\ VALUE = \beta_0 + \beta_1\, Log\ BOOK\ VALUE + \beta_2\, Log\ IT\ INVESTMENT + \beta_3\, AGE + \beta_4 TEACH\ HOSP + \beta_5\, OCCUPANCY + \beta_6\, ALOS + \beta_7\, FTE + e$$

The estimated model in Table 4 (Regression B) extends Tam's model to incorporate several contextual and control variables from the healthcare management literature. In the extended model as well, the coefficient associated with IT investment is positive and statistically significant at the 0.01 level *supporting Hypothesis 1*. Model B, through the inclusion of more control variables explains more variation (about 36 percent) than the earlier estimation model. Further, while occupancy continues to be significantly related to market value, ALOS is not; age and full-time employees are also significantly related to market value. This suggests that *q* and log of market value might have differential relationships to the control variables. To contrast the manner in which the *q*

[9] We included several other control variables such as admissions, beds, inpatient days, location of the hospital, abd Medicare in the analysis and did not observe changes in the sign and significance of the hypothesized relationship.

Table 4. Dependent Variable: *q* Ratio and (Log) Market Value

	Regression A			Regression B†		
	q ratio			Log (Market Value)		
Variables	**Standard Coefficient**	**t-stats**	**VIF**	**Standard Coefficient**	**t-stats**	**VIF**
Ln(BOOK VALUE)				0.13***	2.74	1.072
IT INVESTMENT	0.18***	2.63	1.275			
Ln(IT INVESTMENT)				0.31***	6.78	1.222
AGE	-0.04	-0.94	1.006	-0.10**	-2.49	1.022
TEACH HOSP	0.06	0.96	1.235	-0.02	-0.48	1.213
OCCUPANCY	0.19***	2.63	1.307	0.32***	6.72	1.259
ALOS	-0.18***	-3.83	1.070	-0.01	-0.18	1.080
FTE	-0.042	-0.84	1.026	-0.12***	-2.68	1.068
R-square	*0.23*			*0.39*		
Adjusted R-square	*0.22*			*0.36*		
F-statistic	*18.67*			*22.32*		
p-value	*<0.001*			*< 0.001*		

†Extension of Tam's (1998) model
Significance: *< 0.1, **< 0.05, ***< 0.01

Table 5. Dependent Variables: Return on Assets, Operating Income, Total Net Income

	Return on Assets			Operating Income			Total Net Income		
	(ROA)			(OPINC)			(TOTNETINC)		
Variables	**Std Coeff.**	**t-stats**	**VIF**	**Std Coeff.**	**t-stats**	**VIF**	**Std Coeff.**	**t-stats**	**VIF**
AGE	0.019	0.416	1.062	0.03	0.77	1.062	0.01	0.22	1.062
TEACH-HOSP	-0.062	-1.16	1.430	-0.04	-0.83	1.430	-0.02	-0.86	1.426
OCCUPANY	-0.06	-1.14	1.483	-0.04	-0.83	1.480	0.03	1.32	1.481
ALOS	-0.08	-1.76	1.123	-0.07	-1.62	1.124	-0.016	-0.492	1.124
FTE	-0.152***	-3.252	1.066	-0.046	-1.01	1.066	0.015	0.36	1.066
Ln(BOOK VALUE)	0.073	1.526	1.066	0.01	0.1	1.066	-0.04	-1.26	1.066
Ln(IT INVESTMENT)	0.09	1.185	1.251	-0.06	-0.5	1.249	0.04	1.12	1.249
EBITDA	0.86***	11.57	2.725	0.86***	11.88	2.733	0.92***	32.83	2.733
NPR	-0.31***	-2.71	7.351	-0.16**	-1.8	7.346	-0.04	-1.12	7.340
BED SIZE	-0.12	-1.172	4.812	0.24***	2.54	4.813	0.16***	4.47	4.803
R-sq.	*0.359*			*0.396*			*0.844*		
Adjusted R-sq.	*0.339*			*0.377*			*0.832*		
F-statistics	*17.48*			*21.22*			*162.31*		
p-value	*< 0.001*			*< 0.001*			*< 0.001*		

Significance: *< 0.1, **< 0.05, ***< 0.01

ratio demonstrates value in assessing the contribution of IT investment to firm value as compared to traditional financial measures, we estimated several models using other dependent variables. These include return-on-assets (ROA), operating income, and total net income. Given that senior management places high emphasis on these measures when making executive decisions, we treated them as dependent performance variables to examine the impact of IT investment while controlling for the effect of other contextual variables. The functional form of these models is also consistent with the extant literature (Tam 1998). Results for these models are presented in Table 5. The first observation from these models is that the set of variables employed explain a reasonable amount of variation in the performance measures examined (ranging from 35.9 to 84.4 percent). The second observation from the results in Table 5 is that the coefficient associated with IT investment is not statistically significant in any of the three models.

To examine hypothesis 2 of our study, we estimated a system of equations that combines the dependent variables of *q*, ROA, operating income, and total net income. We conducted a joint F-test that examined if the coefficient for the IT-*q* ratio relationship was statistically significantly different than the coefficients for the IT-ROA, IT-operating income, or IT-total net income relationships. The p-value for this F-test was less than 0.01, indicating support for the value-added contribution of the IT investment–*q* link compared to the IT to the traditional financial and accounting measures links. Thus, Hypothesis 2 is supported.

We conducted a robustness check using components of IT investment: IT salaries and IT support. Results of these estimation models were consistent with our original results in sign and significance. This is expected given that direct IT expenditure in hospitals is highly correlated to IT salary and IT support. Furthermore, from a statistical standpoint, although some subcategories of IT might yield optimal results due to finer granularity, it is likely that the estimate we obtained is actually downward biased, as noted by Anderson et al. (2003) in their study of IT investment and firm performance. In other words, although some studies with more in-depth data (e.g., involving a small number of hospitals) may yield stronger results, the strength of our study is the finding of statistically significant IT influence among a large number of hospitals, thus permitting us to claim broader generalizability.

The most important insight from this set of analyses is that an assessment of the effect of IT investment on hospital performance using only traditional financial metrics would, in fact, point to an insignificant impact. In other words, under the conditions of our study, a technology justification criterion that did not include a measure similar to the *q* ratio might lead one to believe that the contribution of IT investment to firm value is not significant. Overall, our findings provide further evidence to support previous recommendations of the complementarity between the retrospective accounting measures and prospective firm value measure (Amir and Lev 1996).

Comparison with Firm Value of Publicly Traded Hospitals

A robustness check is to compare firm value using the approach outlined in this paper with the exact approach of Chung and Pruitt (1994).[10] Such a comparison is possible in the for-profit sector because of the availability of market value of a hospital. Thus, we acquired data from *Compustat* for publicly traded for-profit healthcare firms with the following criteria: We used SIC codes 8000 to 8099 which included such labels as “Hospitals,” “Health Services,” “Health Care Practitioners,” and “Health and Allied Services” among others. We used data for the number of beds, EBITDA, revenue, and assets. In Approach A, we used the coefficients of the regression model (shown in our price prediction model) and obtained the predicted market value of the for-profit hospitals. In Approach B, we computed Tobin’s *q* using Chung and Pruitt’s formula and thereby obtained the market value of each for-profit hospital.

Specifically, for Approach B, the numerator of Tobin’s *q*, market value, was computed as follows:

Market Value = (fiscal year-end market value of equity + liquidating value of the firms outstanding preferred stock + current liability – current assets + book value of inventories + long term debt)

We were left with 109 observations after accounting for missing observations. A correlation between the market value predicted by our price prediction model (Approach A) and the exact value from the computation of Tobin’s *q* (Approach B) yielded a coefficient of 0.67 with a p-value less than 0.001. This analysis provides further reassurance about the utility of the approach presented in this paper in the absence of market observations on firm value.

Endogeneity Tests

We conducted a two-stage least squares regression to address any potential endogeneity issues. In our case, we used the average IT investment for the past three years as an instrumental variable. Results obtained from the two-stage least

[10]We thank the senior editor and the reviewer for suggesting this analysis.

squares analyses with instrumental variables also provided statistical support (at the 0.05 level) for the relationship between IT investment and *q* ratio. The *t-statistic* was 3.74 and the *p-value* was less than 0.05. These checks of robustness indicate strong support for the relationship between IT investment and a market measure of hospital value providing further reassurance for our original results supporting the hypothesis.

Next, we employed a procedure based on propensity-score matching outlined by Armstrong et al. (2010) to address potential endogeneity issues.[11] Interestingly, this approach has been recommended in recent IS research as well (Mithas and Krishnan 2009). The following steps are conducted in implementing the propensity-score approach:

1. Estimate an ordered logistic model where the dependent variable is quintiles of IT investment, and the independent variables are age, FTE, ALOS, occupancy rate, and teaching hospital status. We split the sample into five quintiles (following Armstrong et al. 2010). Using quintiles has the following advantages: (a) the assumption of a monotonic relationship between IT investment and Tobin's *q* is relaxed and (b) the quintile rankings have better measurement properties than continuous IT investment, especially if data are skewed. The results from this step are propensity scores for each firm (observation).

2. Match the closest propensity scores from step 1 but which also have the maximum difference in the quintile scores. In other words, the matching is done to minimize difference in propensity score and maximize difference in IT investment. The two groups obtained are treatment and control groups.

3. Examine covariate imbalance (for full description, see Armstrong et al.) and remove extreme pairs.

4. Test if the values of Tobin's *q* are significantly different between the treatment and control groups.

The results of the ordered logit model yielded a model that was statistically significant (at the 0.05 level) and explained 20.2 percent of the variance (pseudo R-square). In the next stage, the matching procedure yielded matches with less than 10 percent of the matched pair observations having a difference of at least three quartiles, providing evidence that this approach does a reasonably good job of predicting IT investment levels. We used the nonparametric Kolmogorov-Smirnov (KS) test to confirm that covariate imbalance was not an issue between our experimental and control groups. Finally, a comparison of the experimental and control groups pointed to evidence that IT investment level was a significant driver of Tobin's *q*. In the interests of brevity for this research note, we do not include all of the details of this analysis in the paper. In summary, evidence from the above approaches to address or account for endogeneity rendered valid the results of our original analysis.

[11]We thank the reviewer for suggesting this test for endogeneity.

Discussion

Our findings indicate that IT investment has a positive impact on a firm's market value. We find that IT's impact is best characterized when the firm's market value (*q*) is combined with the traditional accounting metrics in providing a broader picture. For instance, total net income or operating income can provide valuable *retrospective* information about IT's impact upon the erstwhile performance. By comparison, *q* as a dependent variable (in Table 4, Regression Model A) demonstrates statistical significance for IT investment impact on a hospital's *prospective* market value. As an example, the model with ROA as a dependent variable demonstrated statistical significance for FTE, a variable that represents the number of full time equivalent employees. Since the ROA is defined as the difference between revenue and costs divided by total assets, the greater the number of FTEs the higher the labor cost and, therefore, the lower the return on assets. This is an important insight for operational managers to exercise control over patient care costs. With the amount of revenue generally predetermined due to the prospective payment system if the labor costs (FTE) increase, the overall hospital ROA will decline. Therefore, for senior managers, as a complement to the contemporary metrics such as ROA and operating income, the *q* ratio can provide a comprehensive assessment of the firm's retrospective performance *and* the prospective market value.

Contribution

"IT's value can look different depending on the vantage point chosen" (Hitt and Brynjolfsson 1996, p. 138). Our research finds that IT value among NPT healthcare firms can indeed look different from the vantage points of the accounting measures and market measures. As such our findings contribute to academe as well as to practice. Our findings contribute to the academic literature in three primary ways. First, we demonstrate that the *q* ratio, as a forward-looking measure, can be utilized to explore the contribution of IT investment to hospital market value. No previous IS study has examined the influence of IT on firm value of hospitals. By demonstrating the salience of the *q* ratio, our second contribution is to the study of market value of NPT firms. IS researchers can utilize our methodology to gain further insights into the effect of other factors alongside IT investment and examine their impacts on NPT firm value. The third contribution of our study is that it demonstrates the importance of combining accounting measures and a market-based measure to provide a broader picture of IT value. In the absence of the *q*-based prospective insight, the impact of IT might have been deemed not significant and could possibly understate the payoffs of IT investment.

Our contribution to practice is in providing a conceptually grounded, empirically tested, and practically feasible approach to assessing the firm value of NPT hospitals so that managers can measure how IT adds to the firm's market value. Despite the fact that some NPT hospitals are large, multibillion dollar firms, measuring the impact of investments on firm value has been challenging for NPT hospitals due to the lack of equity price, something that their publicly traded cohorts can easily accomplish. Moody's Investor Service projects that recent changes in U.S. healthcare will require not-for-profit hospitals, most of which are also NPTs, to make substantial IT investments to gain operational efficiencies (Goldstein 2010). Further, it forecasts that by using economies of scale hospitals will extract such efficiencies through consolidations and acquisitions. Given these emerging market conditions in which IT's contribution to firm value is critical, NPT hospital managers can find value in following our approach because it adheres to the principles of fair market valuation for NPT firms as endorsed by the United States' GAO. Further, our approach conforms to the principles of private firm valuation proposed by Feldman (2005) and has three features that embody a fair market value: an establishment of an exchange value, a willing buyer and a willing seller, and parties reasonably informed about the entity's true cash flows. Our approach in this research note conforms to these principles by (1) using a market sale price of previous transactions, (2) excluding strategic buys and bankruptcies, and (3) utilizing publicly available metrics of cash flows (EBITDA and revenue) to determine NPT hospital firm value. We believe that our approach to measure IT investments can be extended to assess other investments and their impact on firm valuation, although further validation is needed. It can be useful to other NPT organizations such as utility companies, semi-governmental agencies, industry consortia, mass transit systems and business enterprises that do not have a stock price.

Limitations and Future Research

Notwithstanding the above-mentioned contributions, our study is subject to several limitations. One challenge in adopting our approach to developing a *q* ratio is that it requires an alternate form of market valuation of the NPT firm. In our case, we were able to access and utilize records of hospitals sold to estimate the market value. However, in a more general sense, it may be challenging to arrive at such valuations when sale prices of comparable NPT firms are difficult to gather or are unavailable.

Second, our source data were not sufficiently granular to disaggregate the IT investment into more detailed categories (e.g., directed at specific initiatives) within the hospitals, therefore we are unable to distinguish the impact of the type of IT investment, such as transactional, operational, and managerial control systems, and how each influences the firm's value in our sample of over 400 hospitals. Thus, we made a trade-off between understanding a larger phenomenon of the role of IT in determining firm value against data from a few hospitals with possibly greater granularity of the types of IT investment. Third, our data are based upon United States' hospitals and therefore our findings are generalizable only to U.S. acute care hospitals. However, hospitals in other countries may adopt our methodology by choosing indicators of value that are suitable in their respective economies. Fourth, while we have taken all steps within our control to rule out potential bias in the selection of hospitals, there is still the possibility that reputation effects, self-selection, or other sources of biases might be present. This is particularly the case for the hospital sale and purchase transaction data. We tried to minimize this by identifying and removing strategic purchases.

Finally, although we relied on previous theory, interviews with hospital decision-makers, the GAO guidelines, and excluded bankruptcies and strategic hospital purchases to minimize data bias, it was not possible for us to capture differences in business strategies among hospital buyers or sellers, or to replicate all of the market forces that determine the sale price of a hospital. It is possible that factors such as investments in other types of assets played a role in creating firm value. Yet, we feel confident in the results of our analysis because we capture significant variation (nearly 88 percent) of market value. Despite these limitations, we seek to serve the NPT community by providing a method to understand IT's contribution to the firm value in a pragmatic, yet parsimonious, model that is based on a uniquely constructed data set which includes transactions of *actual* hospital sale records and objective performance data.

Future IS researchers in healthcare and NPT firms can expand their research agenda by deploying market measures, including the *q* ratio, as dependent variables to examine the effects of technology-based processes and investments on the firm, especially when the cost savings and value are realized in the future. Further, future research may also examine what factors moderate firm value in attempting to explain the variance in performance and market value among firms.

Recent studies attribute these factors to IS automation leading to fewer medical errors (Aron et al. 2011), varying levels of IT capabilities (Masli et al. 2011), IT synergies and firm diversification (Ravichandran et al. 2009; Tanriverdi 2006), and learning curves resulting in hospital IT (Mukhopadhyay et al. 2012).[12] Indeed, managers can also assess the effect of other types of investments such as plant and machinery on firm value by utilizing our approach, particularly those enabled by spillovers from IT investment (Chang and Gurbaxani 2012). Managers can assess the payoff of an investment by combining models of long- term impact with models to assess the short-term operational effects of IT on capacity utilization, inventory turnover, and product quality as suggested by Barua et al. (1991). Such comparative analysis will provide insights into the utility functions of various IT initiatives where managers can optimize IT investment decisions—for instance, which IT initiatives enhance firm value even when operational effectiveness is modest?

Our approach conforms to a theoretically expounded dependent variable of firm value (Dehning et al. 2005) and extends Bharadwaj et al.'s (1999) findings to the domain of NPT firms. We hope that this research note will encourage researchers to undertake further research on IT's influence over firm value involving other investment segments such as strategic and competitive, web-based technology (Brynjolfsson et al. 1997) and manufacturing, or in-house versus outsourcing choices.

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References

Amir, E., and Lev, B. 1996. "Value-Relevance of Nonfinancial Information: The Wireless Communications Industry," *Journal of Accounting & Economics* (22:1/3), pp. 3-30.

Anderson, M. C., Banker, R., and Hu, N. 2003. "The Impact of Information Technology Spending on Future Performance," in *Proceedings of the 24th International Conference on Information Systems*, Seattle, Washington, December 14-17, pp. 563-575.

Anderson, M. C., Banker, R. D., and Ravindran, S. 2006. "Value Implications of Investments in Information Technology," *Management Science* (52:9), pp. 1359-1376.

Armstrong, C. S., Jogolinzer, A. D., and Larcker, D. F. 2010. "Chief Executive Officer Equity Incentives and Accounting Irregularities," *Journal of Accounting Research* (48:2), pp. 225-271.

Aron, R., Dutta, S., Janakiraman, R., and Pathak, P. A. 2011. "The Impact of Automation of Systems on Medical Errors: Evidence from Field Research," *Information Systems Research* (22:3), pp. 429-446.

Bacon, C. J. 1992. "The Use of Decision Criteria in Selecting Information Systems/Technology Investments," *MIS Quarterly* (16:3), pp. 335-353.

Balasubramanian, P., Kulatilaka, N., and Storck, J. 1999. "Managing Information Technology Investments Using a Real-Options Approach," *Journal of Strategic Information Systems* (9:1), pp. 39-62.

Barua, A., Kriebel, C. H., and Mukhopadhyay, T. 1991. "An Economic-Analysis of Strategic Information Technology Investments," *MIS Quarterly* (15:3), pp. 313-331.

Benaroch, M. 2002. "Managing Information Technology Investment Risk: A Real Options Perspective," *Journal of Management Information Systems* (19:2), pp. 43-84.

Bharadwaj, A. S., Bharadwaj, S. G., and Konsynski, B. R. 1999. "Information Technology Effects on Firm Performance as Measured by Tobin's *q*," *Management Science* (45:7), pp. 1008-1024.

Bharadwaj, A. S., Keil, M., and Mahring, M. 2009. "Effects of Information Technology Failures on the Market Value of Firms," *Journal of Strategic Information Systems* (18:2), pp. 66-79.

Brynjolfsson, E., and Hitt, L. M. 2000. "Beyond Computation: Information Technology, Organizational Transformation and Business Performance," *Journal of Economic Perspectives* (14:4), pp. 23-48.

Brynjolfsson, E., Hitt, L. M., and Yang, S. K. 2002. "Intangible Assets: Computers and Organizational Capital," *Brookings Papers on Economic Activity* (1), pp. 137-198.

Brynjolfsson, E., Renshaw, A. A., and Van Alstyne, M. 1997. "The Matrix of Change," *Sloan Management Review* (38:2), pp. 37-54.

Cabral, L. 1995. "Sunk Costs, Firm Size and Firm Growth," *Journal of Industrial Economics* (43:2), pp. 161-172.

Chaffee, B. W., and Zimmerman, C. R. 2010. "Developing and Implementing Clinical Decision Support for Use in a Computerized Prescriber-Order-Entry System," *American Journal of Health-System Pharmacy* (67:5), pp. 391-400.

Chang, Y. B., and Gurbaxani, V. 2012. "The Impact of IT-Related Spillovers on Long-Run Productivity: An Empirical Analysis," *Information Systems Research* (23:3), pp. 868-886.

Chari, M. D. R., Devaraj, S., and David, P. 2008. "The Impact of Information Technology Investments and Diversification Strategies on Firm Performance," *Management Science* (54:1), pp. 224-324.

Chung, K. H., and Pruitt, S. W. 1994. "A Simple Approximation of Tobin's *q*," *Financial Management* (23:3), pp. 70-74.

Connolly, R. A., and Hirschey, M. 2995, "Firm Size and the Effect of R&D on Tobin's *q*," *R & D Management* (35:2), pp. 217-223.

Davern, M. J., and Kauffman, R. J. 2000. "Discovering Potential and Realizing Value from Information Technology Investments," *Journal of Management Information Systems* (16:4), pp. 121-143.

[12] We thank the reviewer for suggesting this line of inquiry.

Dehning, B., and Richardson, V. J. 2992, "Returns on Investment in Information Technology: A research synthesis," *Journal of Information Systems* (16:1), pp. 7-30.

Dehning, B., Richardson, V. J., and Stratopoulos, T. 2005. "Information Technology Unvestments and Firm Value," *Information & Management* (42:7), pp. 989-1008.

Devaraj, S., and Kohli, R. 2000. "Information Technology Payoff in the Healthcare Industry: A Longitudinal Study," *Journal of Management Information Systems* (16:4), pp. 41-67.

Dewan, S., and Ren, F. 2011. "Information Technology and Firm Boundaries: Impact on Firm Risk and Return Performance," *Information Systems Research* (22:2), pp. 369-388.

DoBias, M. 2009. "Obama Hails Industry Groups' Cost-Cutting Plans," Modern Healthcare (http://www.modernhealthcare.com/article/20090511/REG/305119944#; accessed May 18, 2010).

Dos Santos, B. L., Peffers, K., and Mauer, D. C. 1993. "The Impact of Information Technology Investment Announcements on the Market Vvalue of the Firm," *Information Systems Research* (4:1), pp. 1-23.

Dos Santos, B. L., Zheng, Z., Mookerjee, V. S., and Chen, H. 2012. "Are New IT-Enabled Investment Opportunities Diminishing for Firms?," *Information Systems Research* (23:2), pp. 287-305.

Efron, B., and Tibshirani, R. 1993. *An Introduction to the Bootstrap*, New York: Chapman & Hall.

Feachem, R. G. A., Sekhri, N. K., and White, K. L. 2002. "Getting More for Their Dollar: A Comparison of the NHS with California's Kaiser Permanente," *British Medical Journal* (324:7330), pp. 135-141.

Feldman, S. J. 2005. *Principles of Private Firm Valuation*, Hoboken, NJ: John Wiley & Sons.

Gapenski, L. C., Vogel, W. B., and Langland-Orban, B. 1993. "The Determinants of Hospital Profitability," *Hospital & Health Services Administration* (38:1), pp. 63-80.

Goldstein, L. 2010. "Transforming Not-for-Profit Healthcare in the Era of Reform," Report Number 124883, Moody's Investors Service, New York (http://content.hcpro.com/pdf/content/251210.pdf; accessed March 14, 2011).

Griliches, Z. 1981. "Market Value, R-and-D, and Patients," *Economics Letters* (7:2), pp. 183-187.

Haux, R. 1998. "Health and Medical Informatics Education: Perspectives for the Next Decade," *International Journal of Medical Informatics* (50:1-3), pp. 7-19.

HCIA. 2001. "Activecontent, Solucient Inc.," Solucient Inc.

Henderson, B., Kobelsky, K. W., Richardson, V. J., and Smith, R. 2010. "The Relevance of Information Technology Expenditures," *Journal of Information Systems* (24:2), pp. 39-77.

Hitt, L. M., and Brynjolfsson, E. 1996. "Productivity, Business Profitability, and Consumer Surplus: Three Different Measures of Information Technology Value," *MIS Quarterly* (20:2), pp. 121-142.

Hitt, L. M., Wu, D. J., and Zhou, X. 2002. "Investment in Enterprise Resource Planning: Business Impact and Productivity Measures*," Journal of Management Information Systems* (19:1), pp. 71-98.

Im, K. S., Dow, K. E., and Grover, V. 2001. "Research Report: A Reexamination of IT Investment and the Market Value of the Firm—An Event Study Methodology," *Information Systems Research* (12:1), pp. 103-117.

Jeong, B. K., and Stylianou, A. C. 2010. "Market Reaction to Application Service Provider (ASP) Adoption: An Empirical Investigation," *Information & Management* (47:3), pp. 176-187.

Kobelsky, K. W., Richardson, V. J., Smith, R. E., and Zmud, R. W. 2008. "Determinants and Consequences of Firm Information Technology Budgets," *Accounting Review* (83:4), pp. 957-995.

Kohli, R., and Devaraj, S. 2003. "Measuring Information Technology Payoff: A Meta-Analysis of Structural Variables in Firm Level Empirical Research," *Information Systems Research* (14:2), pp. 127-145.

Kohli, R., Piontek, F., Ellington, T., Van Osdol, T., Shepard, M., and Brazel, G. 2001. "Managing Customer Relationships through an E-Business Decision Support Application: A Case of Hospital Physician Collaboration," *Decision Support Systems* (32:2), pp. 171-187.

Krishnan, R. A., and Krishnan, H. 2003. "Effects of Hospital Mergers and Acquisitions on Prices," *Journal of Business Research* (56), pp. 647-656.

Langland-Orban, B., Gapenski, L. C., and Vogel, W. B. 1996. "Differences in Characteristics of Hospitals with Sustained High and Sustained Low Profitability," *Hospital & Health Services Administration* (41:3), pp. 385-399.

Lindenberg, E. B., and Ross, S. A. 1981. "Tobin's q Ratio and Industrial Organization," *Journal of Business* (54:1), pp. 1-32.

Madison, K. 2007. "Hospital Mergers in an Era of Quality Improvement," *Houston Journal of Health Law & Policy* (7:2), 265-304.

Marik, M. 1998. "Influence of Capital Structure on Evaluating Companies by Discount Cash Flow Method," *Ekonomicky Casopis* (46:5), pp. 730-746.

Masli, A., Richardson, V. J., Sanchez, J. M., and Smith, R. 2011. "Returns to IT Excellence: Evidence from Financial Performance Around Information Technology Excellence Awards," *International Journal of Accounting Information Systems* (12:3), pp. 189-205.

McCue, M. J., Clement, J. P., and Luke, R. D. 1999. "Strategic Hospital Alliances: Do the Type and Market Structure of Strategic Hospital Alliances Matter?," *Medical Care* (37:10), pp. 1013-1022.

McCutchen, W. W., and Swamidass, P. M. 1996. "Effect of R&D Expenditures and Funding Strategies on the Market Value of Biotech Firms," *Journal of Engineering and Technology Management* (12:4), pp. 287-299.

Melville, N., Kraemer, K., and Gurbaxani, V. 2004. "*Review*: Information Technology and Organizational Performance: An Integrative Model of IT Business Value," *MIS Quarterly* (28:2), pp. 283-322.

Menon, N. M., Lee, B., and Eldenburg, L. 2000. "Productivity of Information Systems in the Healthcare Industry," *Information Systems Research* (11:1), pp. 83-92.

Mithas, S., and Krishnan, M. S. 2009. "From Association to Causality Via a Potential Outcomes Approach," *Information Systems Research* (20:2), pp. 295-313.

Mithas, S., Tafti, A., Bardhan, I., and Goh, J. M. 2012. "Information Technology and Firm Profitability: Mechanisms and Empirical Evidence," *MIS Quarterly* (36:1), pp. 205-224.

Mitenko, G., and Okleshen, H. 1998. "Valuing a Non-Publicly-Traded Business: A Review and Update," *Journal of Legal Economics* (8:2), pp. 33-47.

Mukhopadhyay, T., Singh, P., and Kim, S. H. 2011. "Learning Curves of Agents with Diverse Skills in Information Technology Enabled Physician Referral Systems," *Information Systems Research* (22:3), pp. 586-605.

Palley, T. I. 2001. "The Stock Market and Investment: Another Look at the Micro-Foundations of *q* Theory," *Cambridge Journal of Economics* (25:5), pp. 657-667.

Parente, S. T., and Van Horn, R. L. 2007. "The Value of Hospital Investment in Information Technology in For-Profit and Not-for-Profit Hospitals," *Health Care Financing Review* (28:2), 31-43.

Piontek, F., Kohli, R., Conlon, P., Ellis, J. J., Jablonski, J., and Kini, N. 2010. "Effects of an Adverse-Drug-Event Alert System on Cost and Quality Outcomes in Community Hospitals," *American Journal of Health-System Pharmacy* (67:8), pp. 613-620.

Ramirez, R., Melville, N., and Lawler, E. 2010. "Information Technology Infrastructure, Organizational Process Dedesign, and Business Value: An Empirical Analysis," *Decision Support Systems* (49:4), pp. 417-429.

Ravichandran, T., and Lertwongsatien, C. 2005. "Effect of Information Systems Resources and Capabilities on Firm Performance: A Resource-Based Perspective," *Journal of Management Information Systems* (21:4), pp. 237-276.

Ravichandran, T., Liu, Y., Han, S., and Hasan, I. 2009. "Diversification and Firm Performance: Exploring the Moderating Effects of Information Technology Spending," *Journal of Management Information Systems* (25:4), pp. 205-240.

Sambamurthy, V. 2001. "Editors Comments, Research in Information Systems: What We Haven't Learned," *MIS Quarterly* (25:4), pp. v-xv.

Sambamurthy, V., Bharadwaj, A., and Grover, V. 2003. "Shaping Agility through Digital Options: Reconceptualizing the Role of Information Technology in Contemporary Firms," *MIS Quarterly* (27:2), pp. 237-263.

Santerre, R. E., and Adams, A. S. 2002. "The Effect of Competition on Seserve Capacity: The Case of California Hospitals in the Late 1990s," *International Journal of Health Care Finance and Economics* (2:3), pp. 205-218.

Shi, L. 1996. "Patient and Hospital Characteristics Associated with Average Length of Stay," *Health Care Management Review* (21:2), pp. 46-61.

Stark, P., and Coyne, W. J. 1997. "Not-For-Profit Hospitals," *GAO/HEHS-98-24*, U.S. General Accounting Office, Washington, D.C.

Tam, K. Y. 1998. "The Impact of Information Technology Investments on Firm Performance and Evaluation: Evidence from Newly Industrialized Economies," *Information Systems Research* (9:1), pp. 85-98.

Tanriverdi, H. 2006. "Performance Effects of Information Technology Synergies in Multibusiness Firms," *MIS Quarterly* (30:1), pp. 57-77.

Tanriverdi, H., and Uysal, V. B. 2011. "Cross-Business Information Technology Integration and Acquirer Value Creation in Corporate Mergers and Acquisitions," *Information Systems Research* (22:4), pp. 703-720.

Yayla, A. A., and Hu, Q. 2011. "The Impact of Information Security Events on the Stock Value of Firms: The Effect of Contingency Factors," *Journal of Information Technology* (26:1), pp. 60-77.

Younis, M., Rice, J., and Barkoulas, J. 2001. "An Empirical Investigation of Hospital Profitability in the Post-PPS Era," *Journal of Health Care Finance* (28:2), pp. 65-73.

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Appendix A

Methodology for Predicting Hospital Sale Prices

Drivers of Market Value of Hospitals

We consider three key variables of firm value: EBITDA, bed size, and revenue. Briefly, while EBITDA captures a firm's cash flow through profitability, the bed size of hospitals captures deployable assets. The size of the firm is a stock measure that can influence the market value of a firm because firm size represents the assets with capacity to generate revenue. In a high demand market, firms with greater capacity demand greater value. Similarly, smaller size firms exhibit greater risk and as such increase the risk premium for valuation purposes (Feldman 2005). Firm growth research has emphasized the role of firm size in valuation by viewing it through the lens of the theory of sunk costs (Cabral 1995). Among hospitals, the proxy for firm size is bed size. Bed size (i.e., number of beds) is commonly treated as an asset and previous studies have modeled bed size as an independent variable for hospital profitability (Younis et al. 2001), capacity to form strategic alliances (McCue et al. 1999), the ability to respond to increased competition (Santerre and Adams 2002), and the impact on Tobin's *q* (Connolly and Hirschey 2005).

In summary, previous research indicates that the valuation of hospitals with a greater number of beds can be affected by the hospitals' ability to exercise the capacity to generate business and be more competitive. In addition, revenue represents the consequences of deployable assets to generate profits. Hence, EBITDA, bed size, and revenue contribute to firm value. Previous studies have utilized firm revenue as an independent variable among a basket of measures to calculate market value of firm (Marik 1998) and to explain the variation in market value of biotechnology firms (McCutchen and Swamidass 1996). According to efficiency theory, post-merger efficiencies increase a hospital's total number of available beds and the potential for higher revenue which can impact its market value (Krishnan and Krishnan 2003). (For a detailed justification and suitability of patient revenue for hospitals, see Devaraj and Kohli 2000.) From a conceptual perspective, our three variables reflect the market's assignment of firm value emerging from the firm's current and future profits (Palley 2001). The number of beds accounts for the capacity or the potential of the firm to generate future revenue. NPR captures the current revenue generated given the capacity, thus capturing firm efficiency. We know that while investors would prefer to invest in efficient firms, they are ultimately interested the ability of the firm to generate earnings from such efficiencies.

Price Prediction Model

Hospital data are used to predict the sale price (market value) from the three independent variables using acute care bed size, net patient revenue, and EBITDA. The data set consists of 146 data points. The estimated model is as follows:

$$\text{PRICE} = \beta_0 + \beta_1\text{BED SIZE} + \beta_2\text{NPR} + \beta_3\text{EBITDA} + \text{e}$$

As can be seen from Table A1, over 87 percent of the variation in hospital sale price can be predicted by the variables included in the model: BED SIZE, NPR, and EBITDA. All three independent variables are statistically significant (at the 0.01 level) and in the direction expected.

Table A1. Regression Model for Price Prediction (Dependent Variable: Price)

Variable	Coefficients
BED SIZE	276114.17***
NPR	0.209***
EBITDA	1.176***
R-square	*0.877****
Sample Size	*146*
p-value	*< 0.001*

*** < 0.01

Bootstrap Analysis

Bootstrapping is a technique that enables the estimation of confidence intervals for statistical estimators without assumptions about the distribution. The bootstrap routine builds new samples by randomly selecting with replacements from the original sample that we have, and calculating the estimators using regression. This is repeated several times and the mean is calculated for these estimators. (For details on conducting Bootstrap procedures and analysis, see Efron and Tibshirani 1993.) Each bootstrap sample generates a regression model and the procedure is replicated 1000 times to produce mean value of estimators.

Table A2 shows the mean observations for the least squares estimators with the corresponding bootstrap bias corrected accelerated (BC_a) percentiles. The BC_a confidence intervals adjust the confidence intervals for bias due to small samples by using a normalizing transformation. All estimates for the regression models are within the confidence interval, and the mean of the bootstrapping estimate is close to the observed regression estimate. For example, the 95 percent confidence interval for EBITDA is between 0.0467 and 2.444. We notice that the observed estimate for EBITDA (1.176) lies in this interval. The same is true for Bed Size and NPR. Thus, based on the confidence intervals resulting from bootstrapping, the estimates of our price prediction model are found to be robust estimates.

Table A2. Bootstrap Analysis with Mean Observations for Least Square Estimators

	Observed	**Bias**	**Mean**	**Std. Error**
Bed Size	2.761E+05	-3.199+E04	2.441E+05	7.153E+04
NPR	0.209	0.014	0.223	0.176
EBITDA	1.176	0.106	1.283	0.630
BC_a Percentiles				
	2.5%	**5%**	**95%**	**97.5%**
Bed Size	1.337E+05	1.489E+05	3.576E+05	3.850E+05
NPR	-0.313	-0.242	0.411	0.466
EBITDA	0.0467	0.255	2.146	2.444